DATA QUALITY SUMMARY REPORT FOR AETHALOMETER 1-WAVELENGTH BLACK CARBON DATA COLLECTED BY SONOMA TECHNOLOGY, INC., DURING THE CALIFORNIA REGIONAL $PM_{10}/PM_{2.5}$ AIR QUALITY STUDY

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1. INTRODUCTION AND OBJECTIVES

The purpose of this Data Quality Summary Report is to provide data users with an understanding of the quality of black carbon (BC) data collected by Sonoma Technology, Inc. (STI) for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS). **Table E-1** summarizes the operating sites and times for aethalometer measurements in CRPAQS. The 1-wavelength aethalometer reports $PM_{2.5}$ BC concentrations ($\mu g/m^3$) on a 5-minute basis in standard temperature and pressure (STP). The 5-minute data were also averaged to 60-minute concentrations. This statement provides summary information on data completeness, lower quantifiable limit (LQL), accuracy, and precision. Data completeness was calculated for all sites based on data delivered to ARB; the start date/time indicates the beginning of valid data, continuous until the stop date/time. Data validation suggested that all aethalometer instruments performed similarly; thus, Angiola was used as a representative site to calculate LQL, accuracy, and precision for all aethalometers operated by STI in the study.

Table E-1. Location and duration of aethalometer 1-wavelength measurements performed by STI in CRPAQS.

Site	Start Date/Time	Stop Date/Time
Angiola Trailer	1/14/00 12:35 PST	10/26/00 8:35 PST
Bakersfield	1/20/00 00:00 PST	10/23/00 13:20 PST
Bodega	11/21/00 12:50 PST	2/10/01 18:45 PST
Modesto	10/10/00 00:00 PST	2/6/01 12:05 PST
Sacramento Del Paso	1/20/00 00:00 PST	10/6/00 8:05 PST
San Jose	1/20/00 00:00 PST	10/4/00 10:30 PST
Walnut Grove	11/13/00 12:55 PST	2/13/01 23:50 PST
Walnut Grove Tower	11/14/00 17:40 PST	2/13/01 23:55 PST

Several other documents are available from which to obtain information about the CRPAQS field study and data processing. Sampling locations are described in Wittig et al. (2003). Quality control screening procedures are summarized by Hafner et al. (2003). Results of systems and performance audits and intercomparisons are provided by Bush et al. (2001).

The data quality objectives (DQOs) for 1-wavelength aethalometer BC from instrument specifications are shown in **Table E-2**. A DQO for completeness was not available. The instrument specification DQO for accuracy could not be tested. The 60-minute data met the DQOs for LQL and precision while the 5-minute data did not.

Table E-2. Data quality objectives for aethalometer BC data collected during CRPAQS.

Data Quality Metric	Objective
Lower Quantifiable Limit	0.035 μg/m^3
Accuracy	0.035 μg/m^3
Precision	0.035 μg/m^3

2. DATA COMPLETENESS

Details on data completeness for all aethalometer sites are detailed in **Table E-3**. Data capture quantifies the percentage of total records received versus the number expected during the "period of operation" defined by the start and stop dates/times in Table E-1; the start date/time is the first instance of valid data, and the period of operation is continuous until the stop date/time. The number of valid data points is divided by the number of captured data points to calculate the data recovery. Validity is defined for this calculation as any data point that has a quality control flag of V0 (valid) or V1 (valid but comprised wholly or partially of below-MDL data). Details of data validation are included in Hafner et al. (2003).

Table E-3. One-wavelength aethalometer BC data completeness values for each site.

Monitoring Site	Total No. of Records	No. of Expected Records	Percent Capture[a]	No. of Valid Records	Percent Recovery[b]	No. of Suspect Records	No. of Invalid Records	No. of Missing Records
Angiola Trailer (5-min)	82,321	82,321	100%	77,114	94%	807	1587	2813
Angiola Trailer (60-min)	6861	6861	100%	6302	92%	301	175	83
Bakersfield (5-min)	79,937	79,937	100%	72,617	91%	1297	3222	2801
Bakersfield (60-min)	6662	6662	100%	6227	93%	122	303	10
Bodega (5-min)	23,400	23,400	100%	21,913	94%	138	98	1251
Bodega (60-min)	1951	1951	100%	1785	91%	78	26	62
Modesto (5-min)	34,254	34,254	100%	32,338	94%	4	80	1832
Modesto (60-min)	2856	2856	100%	2838	99%	4	14	0
Sacramento Del Paso (5-min)	74,978	74,978	100%	63,700	85%	6803	216	4259
Sacramento Del Paso (60-min)	6249	6249	100%	5372	86%	595	53	229

[a.] % capture = total number of records/expected records*100
[b.] % recovery = number of valid records/total numbers of records

Table E-3. One-wavelength aethalometer BC data completeness values for each site.

Monitoring Site	Total No. of Records	No. of Expected Records	Percent Capture[a]	No. of Valid Records	Percent Recovery[b]	No. of Suspect Records	No. of Invalid Records	No. of Missing Records
San Jose (5-min)	74,431	74,431	100%	58,987	79%	8654	359	6431
San Jose (60-min)	6203	6203	100%	5035	81%	748	53	367
Walnut Grove (5-min)	26,628	26,628	100%	24,968	94%	545	102	1013
Walnut Grove (60-min)	2220	2220	100%	2107	95%	57	27	29
Walnut Grove Tower (5-min)	26,284	26,284	100%	25,675	98%	79	92	438
Walnut Grove Tower (60-min)	2191	2191	100%	2127	97%	46	16	2

a. % capture = total number of records/expected records*100
b. % recovery = number of valid records/total numbers of records

All sites had a 100% data capture rate. Data recovery rates ranged from 79% (San Jose, 5-minute) to 99% (Modesto, 60-minute).

3. LOWER QUANTIFIABLE LIMIT

The LQL is the lowest concentration in ambient air that can be measured when processing actual samples. Sources of variability that influence the monitored signal at low concentrations include instrument noise and atmospheric variability. As a measure of this variability, two times the standard deviation of selected 5-minute and 60-minute data were used to estimate the LQL. The selected data were taken during periods when concentrations were close to the zero and relatively stable. This is a conservative estimate of the LQL because it includes the concentration variability of the ambient air. Twelve consecutive data values were used to compute the LQL with the 5-minute data and six data values with the 60-minute data; atmospheric variation generally becomes too great after six hours to calculate a reasonable LQL. Since only half the number of data values were used in the calculation (see "N" in Equation E-1), the 60-minute LQL is expected to be higher than the 5-minute LQL, despite the "smoothing" that occurs when averaging 5-minute to 60-minute values.

The LQL is calculated as shown in Equation E-1. **Table E-4** shows the LQL, as well as the specific data strings used to calculate the LQL. The LQL for the 60-minute data meets the instrument specification DQO; the 5-minute LQL does not.

$$\mathrm{LQL} \approx 2s = 2\sqrt{\frac{\sum (aeth - \overline{aeth})^2}{N-1}} \qquad \textbf{(E-1)}$$

where:

$\overline{aeth}$ = mean BC concentration

N = number of measurements

σ = standard deviation

Table E-4. Time period used to calculate LQL, the LQL, and the corresponding mean concentration during the selected time period.

Type of Data	Dates and Times Used for LQL Calculation	LQL (μg/m^3)	Mean (μg/m^3)
5-minute	1/25/00 17:50 – 18:50 PST	0.08	0.06
60-minute	9/2/00 10:00 – 16:00 PST	0.01	0.07

4. ACCURACY

Calibration data for the aethalometer is not available since it cannot be calibrated in a similar manner to instruments measuring gaseous species. Validation flow checks were performed periodically on the aethalometer; these checks can be used to evaluate the accuracy of the flow through the instrument throughout the study. This technique quantifies the variability of the measured flow from the periodic flow checks. While not the true accuracy of the BC concentration measured by the aethalometer, if most of the error is assumed to be due to flow changes, this method provides a sufficient surrogate.

Accuracy can be expressed in terms of the 95% confidence interval (CI). For aethalometer measurements, the 95% CIs were calculated from the differences between the monitor's measured flow and the known flow provided by the flow checks. The 95% CI approximates the accuracy of the data as shown in Equation E-2.

$$\text{Accuracy} \approx 95\%\ \text{confidence interval} = \frac{1.96\left(\frac{s_{flowcheck}}{\sqrt{N}}\right)}{\left[\overline{aeth}\right]_{flowcheck}} \times 100\% \qquad \textbf{(E-2)}$$

where:

$$s_{flowcheck} = \sqrt{\frac{\sum (x - \bar{x})^2}{N-1}}$$

$$x = [\text{aeth}]_{\text{flowcheckl}} - [\text{aeth}]_{\text{measured}}$$

$$\bar{x} = \frac{\sum \left([\text{aeth}]_{\text{flowcheck}} - [\text{aeth}]_{\text{measured}}\right)}{N}$$

$[aeth]_{flowcheck}$ = aethalometer true flow as per flow check.

$[\text{aeth}]_{\text{measured}}$ = flow measured during flow check by the aethalometer.

Periodic flow checks were performed at all sites; Angiola is used as the representative site for all aethalometers operated by STI during CRAPQS. The average flow measured during

flow checks, $\left[\overline{\text{aeth}}\right]_{\text{measured}}$, was calculated by averaging the measured flows during the periodic flow checks. The 95% CIs and the number of flow checks used to estimate the CIs for aethalometer BC at Angiola are provided in **Table E-5**. This is applicable to both 5-minute and 60-minute data.

Table E-5. Accuracy and number of flow check data points used for the aethalometer BC measurements at the representative site, Angiola.

No. of Flow Checks Used	Accuracy
22	1.9%

5. PRECISION

Precision can be measured for the aethalometer by evaluating the variance of BC concentrations during a period of low variability, when atmospheric influence on variability is assumed to be minimal. Five-minute and 60-minute data were selected during periods of low variability, but when concentrations were well above the LQL. The precision was then evaluated by calculating the coefficient of variation (CV) during the period of low variability, as shown in Equation E-3.

$$\text{Precision} \approx \text{CV} = \frac{\sigma_{\text{measured}}}{\left[\overline{\text{aeth}}\right]_{\text{measured}}} \times 100\% \qquad \textbf{(E-3)}$$

where:

$$\sigma_{\text{measured}} = \sqrt{\frac{\sum\left(\left[\text{aeth}\right]_{\text{measured}} - \left[\overline{\text{aeth}}\right]_{\text{measured}}\right)^2}{\text{N}-1}}$$

All the BC concentrations in Equation 5-1 refer to the concentrations measured during the selected time period. **Table E-6** shows the precision calculated for the representative site, Angiola. At the mean values given, the 60-minute data meet the DQO while the 5-minute data do not.

Table E-6. Precision, the number of data points, time period, and mean BC concentration used to calculate the precision of the aethalometer at the representative site, Angiola.

Interval	No. of Data Points Used	Date and Time	Precision	Mean ($\mu g/m^3$)
5-minute	12	10/20/00 03:00 – 04:00 PST	3.1%	1.85
60-minute	8	4/27/00 14:00 – 22:00 PST	9.2%	0.33

6. REFERENCES

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